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Revitalization of Naval Surface Warfare Center Excellence in Early Stage Combat System Engineering

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14. ABSTRACT

For at least a decade, the surface Navy community has abdicated roles to industry in early stage ship concept exploration, requirements definition, and architecture development. Since the late 20th century, industry was given these roles in the hopes that freedom to innovate in a competitive environment would result in performance improvements combined with cost savings and acceleration of delivery. This initiative, known as ?Acquisition Reform,? resulted in some unintended consequences such as lack of cost realism, exacerbation of interoperability problems, and increased total ownership cost due to increased system variations. As a result, the surface Navy community has reestablished its role in early stage ship design processes to avoid future problems and to manage and engineer systems with focus toward an enterprise approach. To adapt to its revitalized role, the Naval Surface Warfare Center (NSWC) instituted a concerted effort to reinvigorate early stage ship and mission system design capabilities. The NSWC is bolstering organizational capabilities in the areas of people skills, processes, communications, tools, and industry interactions to ensure implementation of the most effective design to support the force and warfighters within the current austere budget environment. The Naval Surface Warfare Center, Dahlgren Division (NSWCDD), in concert with the other Surface Warfare Centers, has been building on its existing foundation for the development of analysis, requirements, and architecture. This is not being done to the exclusion of industry in the equation in that the talents and experience of all combat system design contributors must be brought to bear in this restricted-funding environment but in the appropriate roles while recognizing each organization?s strengths. The authors of this paper investigated four key aspects to the combat systems engineering responsibilities in early stage combat system design that are consistent with NSWCDD Strategic Plan.

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Preface & Acknowledgements

Welcome to our Ninth Annual Acquisition Research Symposium! This event is the highlight of the year for the Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) because it showcases the findings of recently completed research projects—and that research activity has been prolific! Since the ARP's founding in 2003, over 800 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 60 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a "broker" to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and hope this symposium will spark even more participation.

We encourage you to be active participants at the symposium. Indeed, active participation has been the hallmark of previous symposia. We purposely limit attendance to 350 people to encourage just that. In addition, this forum is unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. Seldom will you get the opportunity to interact with so many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. In the words of one senior government official, "I would not miss this symposium for the world as it is the best forum I've found for catching up on acquisition issues and learning from the great presenters."

We expect affordability to be a major focus at this year's event. It is a central tenet of the DoD's Better Buying Power initiatives, and budget projections indicate it will continue to be important as the nation works its way out of the recession. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you're a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

- Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)
- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
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- Program Executive Officer, Integrated Warfare Systems
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- Director of Open Architecture, DASN (RDT&E)
- Program Executive Officer, Littoral Combat Ships

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this symposium.

James B. Greene Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 12. Revitalizing the Ship Design and Shipbuilding Process

Wednesday, May 16, 2012	
3:30 p.m. – 5:00 p.m.	**Chair: Robert "Bob" G. Keane Jr.,** President, Ship Design USA, Inc. ***International Naval Technology Transfer: Lessons Learned from the Spanish and Chilean Shipbuilding Experience*** Larrie Ferreiro, *Defense Acquisition University* ***Total Ship Design Process Modeling*** David A. Helgerson, *CSC Advanced Marine Center* Seth Cooper, *NAVSEA05C* Gilbert Goddin, *Naval Surface Warfare Center, Dahlgren* Gene Allen, *Naval Surface Warfare Center, Carderock Division* Daniel Billingsley, *Grey Ghost, LLC* Sean Gallagher, *Naval Surface Warfare Center, Carderock Division* ***Revitalization of Naval Surface Warfare Center Excellence in Early Stage Combat System Engineering*** Ashby Hall, Terence Sheehan, and Mark Williams *Naval Surface Warfare Center, Dahlgren*

Robert "Bob" G. Keane Jr.—Mr. Keane is the president of Ship Design USA, Inc. Prior to starting his own consulting firm, Mr. Keane worked at the Advanced Marine Center of CSC and at the Naval Sea Systems Command (NAVSEA) for 35 years. Mr. Keane was a member of the Senior Executive Service (SES) for 21 years. He last served as executive director of the Surface Ship Design and Systems Engineering Group in NAVSEA. He also served as director of the Total Ship Systems Directorate (Code 20) at the Naval Surface Warfare Center Carderock Division (NSWCCD). Mr. Keane previously held senior leadership positions in NAVSEA as chief naval architect and deputy director, Surface Ship Design and Systems Engineering Group; technical director, Ship Design Group; director, Ship Survivability Sub-Group; director, Naval Architecture Sub-Group; director, Hull Form Design, Stability and Hydrodynamics Division; head, Hull Equipment Branch; and as a ship arrangements design specialist.

Mr. Keane is widely recognized as an expert in naval ship design, is a plank holder in the Navy's Center for Innovation in Ship Design at NSWCCD, and has fostered the professional development of engineers and scientists in government and industry. He received his Bachelor of Engineering Science in mechanical engineering from Johns Hopkins University, his Master of Science in Engineering in ship hydrodynamics from Stevens Institute of Technology, and his Master of Science in Engineering in naval architecture and marine engineering from the University of Michigan.

Mr. Keane is currently serving as chair of the American Society of Naval Engineers (ASNE) and Society of Naval Architects and Marine Engineers (SNAME) Joint Ship Design Committee, as a member of the ASNE-SNAME Joint Education Committee, as a member of the SNAME Technical & Research Steering Committee, and ex-officio member of the ASNE-SNAME Strategic Alliance Committee and he is a current member of the ASNE National Council. He recently served as chair of the highly successful ASNE-SNAME International Electric Ship Design Symposium (ESDS) in February 2009, and has served as chair of the ASNE Flagship Section, chair of the SNAME Chesapeake Section, president of the Association of Scientists and Engineers (ASE) of NAVSEA, regional vice president of SNAME, and president of the D.C. Council of Engineering and Architectural

Societies. He has held numerous other leadership positions in these societies, and has published frequently in the *Naval Engineers Journal* and *Journal of Ship Production*.

Mr. Keane has received many honorary awards including the Secretary of the Navy Distinguished Civilian Service Award, Department of the Navy Superior and Meritorious Civilian Service Awards, SNAME David W. Taylor Medal, ASE Silver Medal, ASE Professional Achievement Award, SNAME Distinguished Service Award, two SNAME Elmer Hann Awards for Best Paper, ASE John Niedermair Award for Best Paper, and election as a Fellow of SNAME. Mr. Keane and his wife, Judy, have three sons and four grandchildren. [keanerg@comcast.net]

Revitalization of Naval Surface Warfare Center Excellence in Early Stage Combat System Engineering[1]

Ashby Hall—Hall is a systems engineer in the Warfare Systems Definition Branch at NSWCDD. She earned a BS in computer science from Mary Washington University in 2003 and an MS in systems engineering from George Mason University in 2007. Hall has 11 years of experience working Joint and naval systems engineering initiatives. Her experience emphasizes front-end systems engineering competencies, specifically requirements, architecture, and systems engineering planning. Hall currently supports AEGIS Modernization and Surface Navy Enterprise systems engineering initiatives.

Terence Sheehan—Sheehan is a principal systems engineer at NSWCDD with 25 years of experience. He earned his BS in mathematics from the College of William and Mary in 1987 and his MS in systems engineering from Virginia Polytechnic Institute and State University in 1999. Sheehan has provided systems engineering expertise spanning numerous ship classes, including AEGIS, aircraft carriers, arsenal ship, DDG 1000, Littoral Combat Ship, and Future DDG 51 Flights. He has worked on future ship concepts, combat system technologies, requirements, architecture, and design and ship integration.

Mark Williams—Williams is a principal systems engineer at NSWCDD with 37 years of experience. He received his BS in aerospace engineering from the University of Maryland in 1975 and his MS in mechanical engineering from the Catholic University of America in 1987. For over two decades, he worked in the area of underwater acoustic signal processing for surface ship, submarine, air, and surveillance sensor systems. He subsequently worked in developing antisubmarine warfare data fusion systems for surface ships. More recently, he has spent over 10 years developing the requirements and architectures for DDG 1000, PCU *Gerald R. Ford* (CVN 78), LCS, CG(X), AEGIS Modernization, and DDG 51 Flight III.

Abstract

For at least a decade, the surface Navy community has abdicated roles to industry in early stage ship concept exploration, requirements definition, and architecture development. Since the late 20th century, industry was given these roles in the hopes that freedom to innovate in a competitive environment would result in performance improvements combined with cost savings and acceleration of delivery. This initiative, known as "Acquisition Reform," resulted in some unintended consequences such as lack of cost realism, exacerbation of interoperability problems, and increased total ownership cost due to increased system variations. As a result, the surface Navy community has reestablished its role in early stage ship design processes to avoid future problems and to manage and engineer systems with focus toward an enterprise approach. To adapt to its revitalized role, the Naval Surface Warfare Center (NSWC) instituted a concerted effort to reinvigorate early stage ship and mission system design capabilities. The NSWC is bolstering organizational capabilities in the areas of people skills, processes, communications, tools, and industry interactions to ensure implementation of the most effective design to support the force and warfighters within the current austere budget environment.

The Naval Surface Warfare Center, Dahlgren Division (NSWCDD), in concert with the other Surface Warfare Centers, has been building on its existing foundation for the development of analysis, requirements, and architecture. This is not being done to the exclusion of industry in the equation in that the talents and experience of all combat system design contributors must be brought to bear in this restricted-funding environment but in the appropriate roles while recognizing each organization's strengths. The authors of this paper investigated four key aspects to the combat systems engineering responsibilities in early stage combat system design that are consistent with NSWCDD Strategic Plan.

[1] The views expressed in this paper are those of the authors and do not reflect the official policy or position of the Department of the Navy, the Department of Defense, or the U.S. Government.

Overview

For at least a decade, the surface Navy community has abdicated roles to industry in early stage ship concept exploration, requirements definition, and architecture development. Since the late 20th century, industry was given these roles in the hopes that freedom to innovate in a competitive environment would result in performance improvements combined with cost savings and acceleration of delivery. This initiative, known as "Acquisition Reform," resulted in some unintended consequences such as lack of cost realism, exacerbation of interoperability problems, and increased total ownership cost due to increased system variations. As a result, the surface Navy community has reestablished its role in early stage ship design processes to avoid future problems and to manage and engineer systems with focus toward an enterprise approach. To adapt to its revitalized role, the Naval Surface Warfare Center (NSWC) instituted a concerted effort to reinvigorate early stage ship and mission system design capabilities. The NSWC is bolstering organizational capabilities in the areas of people skills, processes, communications, tools, and industry interactions to ensure implementation of the most effective design to support the force and warfighters within the current austere budget environment.

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The Pendulum

One can invoke the concept of the pendulum slightly swinging back from industry to government, regarding the responsibilities for technical engineering in early stage system design. In this way, the responsible Navy organizations can more convincingly claim to themselves and leadership that technologies, systems, and products to be developed and procured have a higher chance of being actualized and meeting warfighter requirements on schedule and within budget. These objectives were actually the intention for instituting Acquisition Reform and appear to be an adjustment to the implementation of this mandate, under the objective of "continuous process improvement," based on lessons learned. As stated in a reprint of the directive on the Defense Acquisition University website, "DoD will institutionalize business processes that facilitate affordable and timely delivery of best-value products and services to meet warfighter needs. DoD will also create and maintain an environment for continuous process improvement while supporting the nation's social policies, protecting the public trust and fostering development of an integrated national industrial and technology base" (Secretary of Defense, 1994).

It is imperative that the government does not lose sight of its responsibilities for setting system performance requirements, ensuring value to the taxpayer, and ultimately, ensuring the warfighters' success and safety in executing mission goals. Former Secretary of Defense Robert Gates pointed out,

> We must ensure that requirements are reasonable and technology is adequately mature … program cost estimates are realistic. … [We] adequately staff the government acquisition team, and provide disciplined and constant oversight. … [We] must constantly guard against so-called

> ‘requirements creep,’ and validate the maturity of technology at milestones. (*From 10 Pentagon Insiders*, 2011).

It is important to apply the value of the government’s early contributions in the acquisition. Based on the commitment of life cycle cost early in the design process, it is estimated that two-thirds is vested by Preliminary Design and roughly four-fifths by the end of Detailed Design (Fabrycky & Blanchard, 1991). Therefore, it is critical that a significant investment in technical and programmatic analysis should be allocated to these phases.

Accountability

Figure 1 depicts the allocation of the Technical Authority (TA) and Program Authority (PA) in the Navy acquisition organization. In order to reset roles and responsibilities in the new engineering environment, Naval Sea Systems Command (NAVSEA) issued an updated NAVSEANOTE 5400 reestablishing definitions and responsibilities for Technical Authority:

> Technical Authority. Reference (b) defines technical authority as the authority, responsibility, and accountability to establish, monitor, and approve technical standards, tools, and processes in conformance with applicable DoD and DON policy, requirements, architectures, and standards. The SYSCOM Commander responsibilities include serving as the technical authority and operational safety and assurance certification authority for their assigned areas of responsibility. Reference (a) defines Naval SYSCOM engineering and technical authority policy and requires Technical Warrant Holders (TWHs) to be qualified, warranted, empowered, and entrusted to make technically sound engineering decisions, and support Program Managers and the Fleet in providing best value engineering and technical products. (Commander, NAVSEA, 2010)

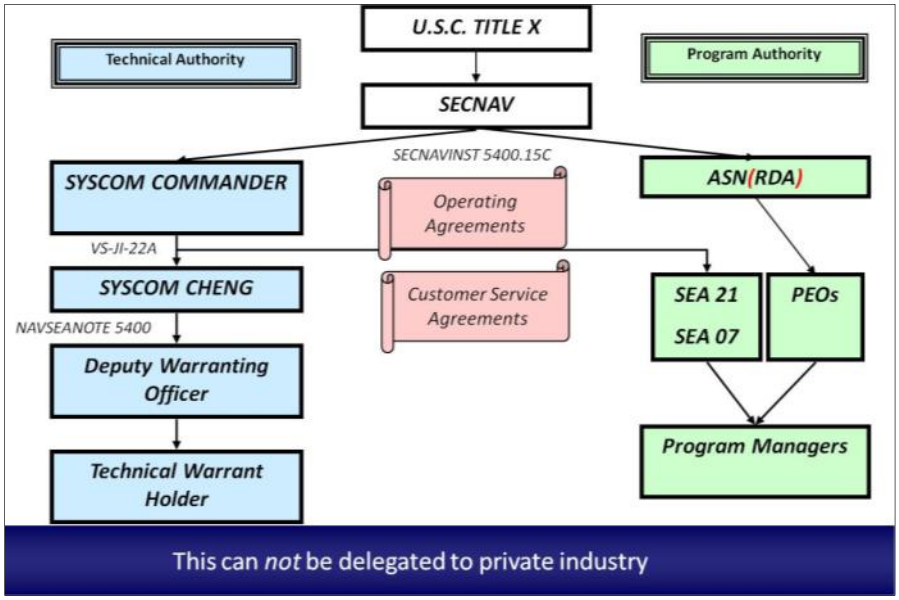

Figure 1. Allocation of the Technical Authority and Program Authority in the Navy Acquisition Organization

In addition, the TWHs have established pyramids of experts who assist them in making judgments regarding technical requirements, technology feasibility, and risks in implementation of their vested authorities. NAVSEANOTE 5400 (Commander, NAVSEA, 2010) cites TWHs by name and organization. TWHs are, by requirement, NAVSEA mission-

funded employees, yet their supporting experts within the pyramids are comprised of scientist and engineers from Systems Commands (SYSCOMs), Warfare Centers, and Federally Funded Research and Development Center organizations. The Warfare Centers maintain a knowledge base and capability in the Technical Competencies (TCs) assigned to their organizations that is based on historical technical capability and allocations obtained through base realignment and closure decisions. The NSWCDD TCs are not mission funded and rely on a majority of the funding from the program managers, which can at times create difficulties regarding the multiplicity of reporting chains. However, it would not make good fiscal policy to attempt to create multiple pyramids of expertise (one for TA and one for PA). In reality, the TA process has been tested on several recent early stage design studies, the Maritime Air and Missile Defense of the Joint Forces Analysis of Alternatives, Radar Hull Study, and DDG 51 Flight III, to name a few, and appears to provide positive results.

Critical Aspects of Combat Systems Engineering

NSWCDD is working to reinforce many critical combat systems engineering capabilities to support early stage combat system design while building upon critical interactions required between combat systems engineering and the other design disciplines, including ship systems; aviation systems; command, control, communications, computers, and intelligence (C4I) systems; and support systems. We posit four key aspects summarized as (1) the need to understand and provide engineering expertise at multiple levels of Navy requirements, architecture, and design, particularly beginning at Force Level; (2) recommendations for sound technical innovations and system evolutions grounded within realistic risk assessments; (3) focus on continual development of expert capabilities within our people regarding our core technical capabilities; and (4) Warfare Center collaboration to realize the advantages of total ship system integration. Each of these focus areas will enhance NSWCDD's success to support the objectives and implementation of technical authority in early stage design.

Force Level Assessments

Combat systems engineers need to maintain an awareness of the pressures being placed on the operational and acquisition communities and understand the correlation of these pressures on the evolution of fleet force composition including associated combat systems architecture. These pressures include changes in adversary capabilities, national military strategic objectives, and real-world constraints, whether budgetary or diplomatic. Combat systems engineering should be conducted in the context of an enduring assessment of force-level drivers. Because it takes 10, 20, or even 30 years to effect a significant change in a force capability, given the development time constant for implementation of numbers of new ships and mission capabilities, combat systems engineers are required to conduct assessments based on long-term analysis that need to address multiple alternative futures. As with all projections, uncertainty is inherent in the variability of future outcomes, yet these can be bounded with some percentage of potential. It is somewhat of a guessing game but can be based on the analysis of expert prognosticators and intelligence collection. This type of work was started under NAVSEA 05D1 in 2004 under the Future Force Formulation program , which assembled a group of ship and mission systems engineers working with a number of these expert prognosticators. The project has evolved several times under different monikers and continues to thrive with contributions from the combat systems engineering community. The key objective is creating a synergy between combat system design and force structure planning.

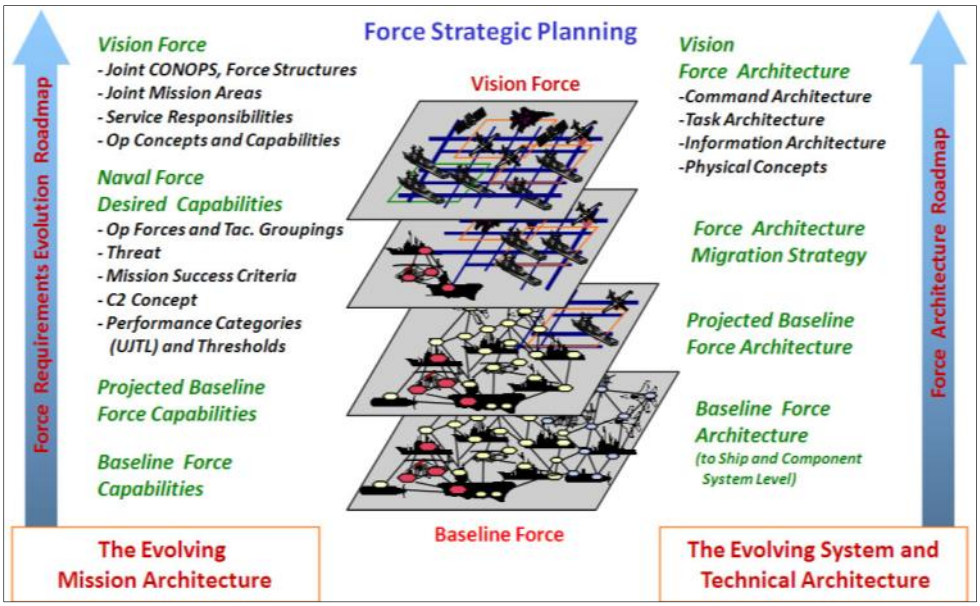

Figure 2. Force Strategic Planning

Optimization of Combat System Investments

NSWCDD provides, through its TCs, analysis estimating the value of combat system requirements, architectures, and technologies regarding contributions to future warfighting scenarios. With withering budgets and a shrinking force structure, there has been an increased focus on "enterprise" thinking in terms of the benefits associated with system commonality and modularity across ship classes, as well as increased investment in the application of "force multipliers" through networking and intelligent, coordinated, force-level, tactical decision making. For over a decade, NSWCDD has been a key contributor in the pursuit of enterprise-level implementation of common software architecture and components across ship classes and combat systems. This sizeable effort has taken on many names over the years, but is currently known as Product Line Architecture (PLA). PLA is just beginning to experience successes, particularly in the implementation of Advanced Capability Build 12 (ACB 12); and others are on the horizon in ACB 16. PLA implements practices of quality architecture attributes similar to those espoused by the Carnegie Mellon Software Engineering Institute, an established center of excellence for software engineering. NSWCDD is working in concert with a national team of organizations to establish the Common Source Libraries, which provide techniques for reducing the cost of developing baselines within a single ship class, and Common Asset Libraries, providing a set of assets available to any and all combat system developers for reuse. One objective of the renewed TA implementation is to avoid increases in system variations that lead to increases in total ownership cost for development, testing, training, and maintenance. For example, the Littoral Combat Ship program implemented two completely different combat system hardware and software designs to support the same mission, and added a considerable quantity of new system elements not currently supported in the Navy's programs. NSWCDD has supported the Program Executive Office Integrated Warfare Systems for years in developing execution plans based on best value investments, systems variation reductions, and software capability sharing through common system architecture concepts. Recently, NSWCDD has provided expertise, as a key contributor to nationally organized teams, in evaluating "game-changer" technologies, and continues to investigate requirements for integrating these technologies. For example, NSWCDD has conducted mission analysis and

developed system architecture products for the Air and Missile Defense Radar, Railgun, and Laser Weapon System.

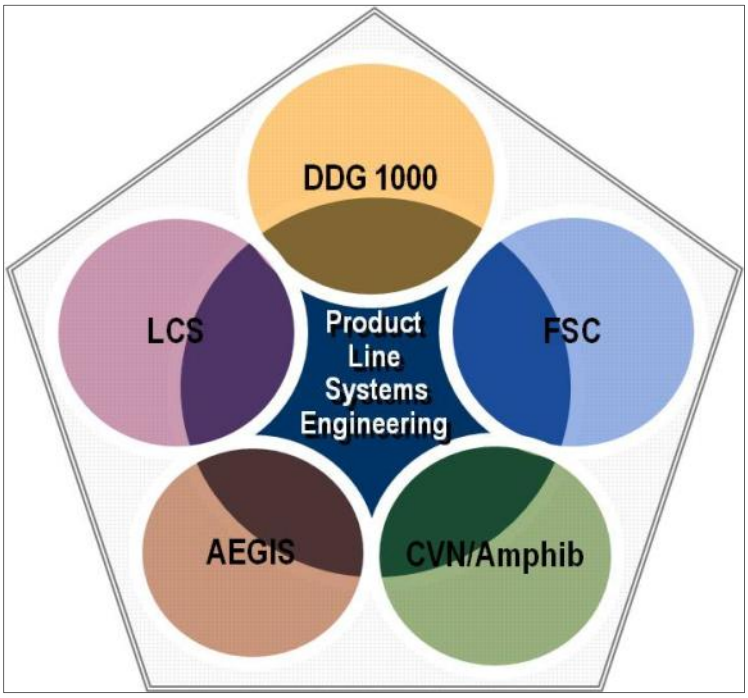

Figure 3. Product Line Systems Engineering

Building the Pyramid of Expertise

NSWCDD management and technical leadership are proactive, ensuring the enduring provision of excellence within its TC areas to support higher echelon technical and program management organizations. This focus is provided through a number of workforce development assessments and actions that are periodically revisited in strategic planning and implemented daily through concerted training and mentoring. NSWCDD has several personnel with the expertise to fill TWH roles awarded through a competitive process. These awards are made based on the knowledge established through years of relevant experiences and surface Navy community standing. Concurrently, the organization is making a concerted effort to assess the needs for maintaining the inherent technical capabilities and supporting the TWH pyramids. These assessments lead to a number of best practices regarding hiring and promoting to maintain a continuum of TC depth. Also required is a management approach to ensure effective and focused training plans that include continued education as well as tutelage provided by experienced professionals, and by providing appropriate rotational assignments for developing broad combat system knowledge.

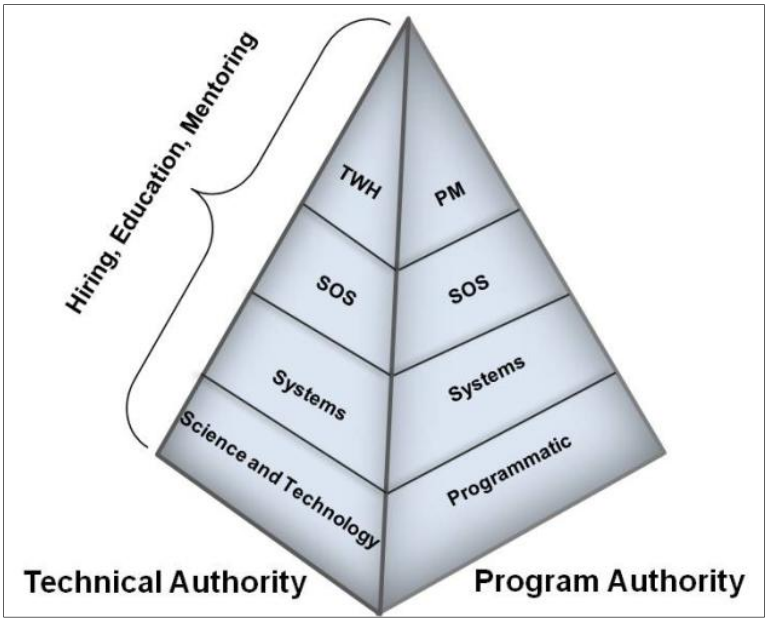

Figure 4. Technical Authority and Program Authority Pyramid

SYSCOM and Warfare Center Collaboration

The SYSCOMs and Warfare Centers have been forming teams of experts to address early stage ship design and to ensure there is a Total Ship Systems Engineering focus. This was first implemented in the DDG 1000 program. The Office of Naval Research, in concert with NAVSEA organizations, has established a ship and mission system design process effort and tool development to understand the technical process requirements for Exploratory, Preliminary, and Detailed design. The process is being developed to infuse an understanding of each community's processes, sub-process products, interactions, applicable expertise, scheduling, and cost. The project is attempting to integrate and institutionalize the processes performed across the major ship design areas of ship Hull, Mechanical, and Electrical; combat systems, C4I, aviation, and support.

Summary

NSWCDD is a crucial component in the application of technical excellence in early stage ship and combat system design. This responsibility is recognized and efforts at all levels of the organization are in place to ensure it is effectively and efficiently provided. With the changes in the budget environment, it is of the utmost importance to apply these technical capabilities from a force- and enterprise-level perspective. That perspective needs to be further extended to integration with the other ship design areas in search of additional efficiencies in total ship system acquisition. Warfare Center technical expertise has always been an intrinsic; it is our responsibility to ensure its continuation and growth.

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Revitalization of Naval Surface Warfare Center Excellence in Early Stage Combat Systems Engineering

9th Annual Acquisition Research Symposium

16–17 May 2012

Terence J. Sheehan

Naval Surface Warfare Center, Dahlgren Division

Overview

- Discuss how the Naval Sea Systems Command (NAVSEA) enterprise is responding to lessons learned from contemporary early stage ship and mission system development efforts
- The Naval Surface Warfare Centers are an integral part of early stage ship design, responding to changes in the evolution of acquisition improvements
- Topics:
  - The Pendulum
  - Technical Accountability
  - Four Critical Aspects of Combat Systems Engineering
  - Summary

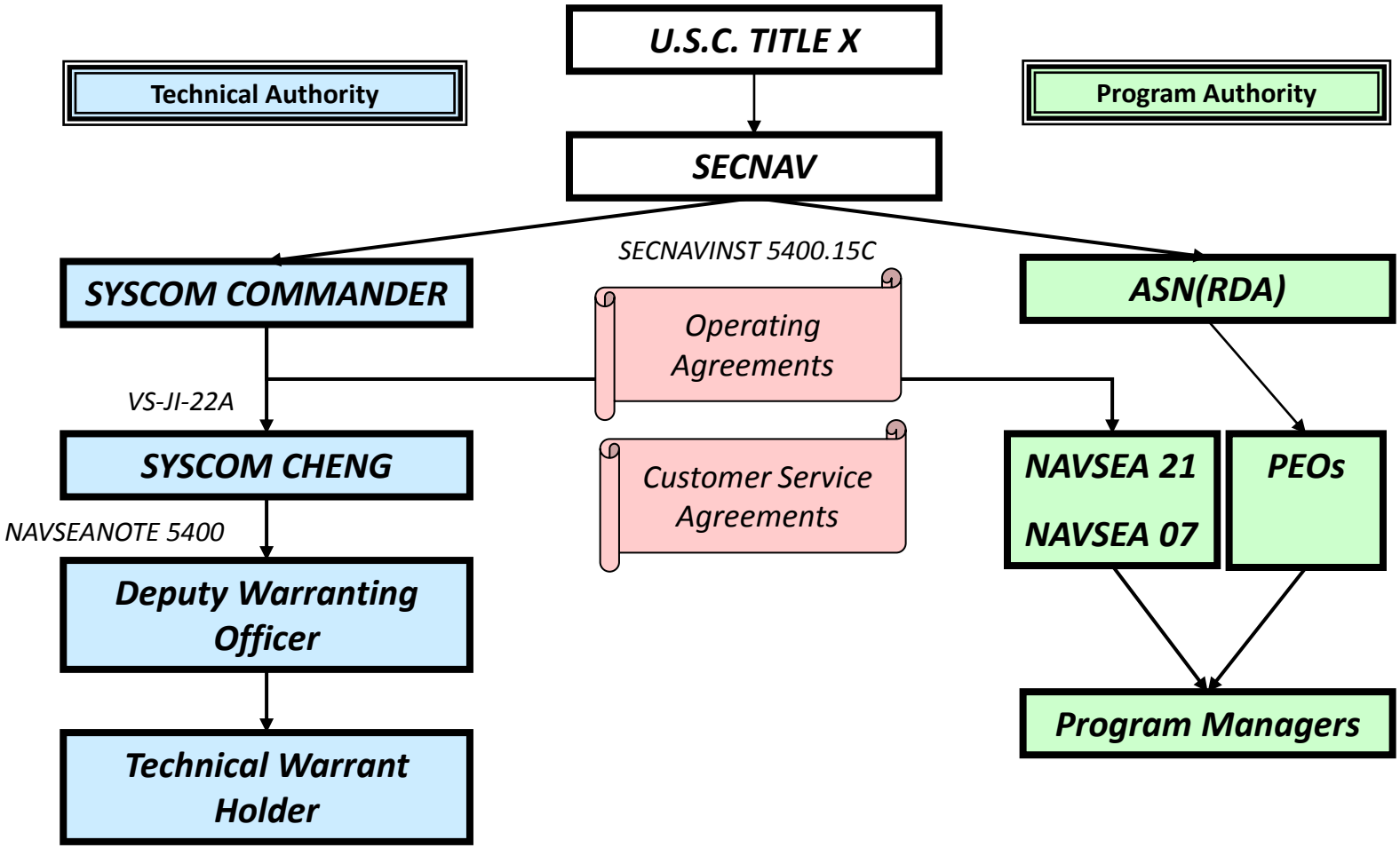
U.S. Navy-released photo

The Pendulum

- Acquisition reform was created to "institutionalize processes that facilitate affordable and timely delivery of best-value products to meet the warfighter needs"
- The Navy community is instituting changes based on lessons learned from Arsenal Ship, DDG 1000, and Littoral Combat Ship projects in their approach to early stage design while retaining the positive aspects of these programs
- NSWCDD provides an increased technical role in the implementation of technical authority to support the NAVSEA enterprise

U.S. Navy-released photos

Technical and Program Authorities



This can *not* be delegated to private industry

NAVSEA WARFARE CENTERS DAHLGREN

Technical Capabilities

Analysis
• Warfare Analysis
• Systems Analysis
• Cost Analysis
• Engineering Analysis
• Operational Systems Analysis

Science and Technology (S&T)
• Materials
• Physics
• Chemistry
• Biology
• Numerical Analyses and Algorithm Development
• Emergent Technologies
• Complexity science and Networks
• Computer Science

Test and Evaluation (T&E)
• R&D Test Engineering
• Integrated Systems Operational T&E
• Data Collection & Analysis
• T&E Quality Management
• Test Execution Operations
• Software T&E

Software Engineering and Integration (SWE&I)
• Software Architecture Engineering
• Software Requirements Analysis
• Software Design & Development
• Real-time Software Design and Development
• Software Integration
• Software Integration Testing
• Software Quality Assurance
• Software Lifecycle Support
• Software Engineering Management

Warfare Systems Engineering and Integration (WSE&I)
• Requirements Engineering
• Architecture Engineering
• Integration & Interoperability
• Systems Engineering Management (e.g., configuration management, requirements management, cost)
• Operational Engineering Support
• System Design and Integration
• System Certification
• Early System Engineering
• Systems Engineering

Combat System Element Engineering (CSEE)
• Systems Safety
• Aero vehicle Engineering
• CBR Defense Systems Science and Engineering
• Directed Energy Science and Engineering
• Electromagnetic Environmental Effects
• Electro-optic Systems Science and Engineering
• Geographic Information Systems Engineering
• Human Systems Integration
• Information Ops Engineering
• Information Security Engineering
• Integrated Topside Design
• Missile & Launchers Systems Integration
• Munition and Gun Weapons Systems Engineering
• Project Management
• Pulsed Power Science and Engineering
• Radar Systems Science and Engineering
• Natural Environment Effects on Systems
• Electronic Warfare
• Sensor Fusion

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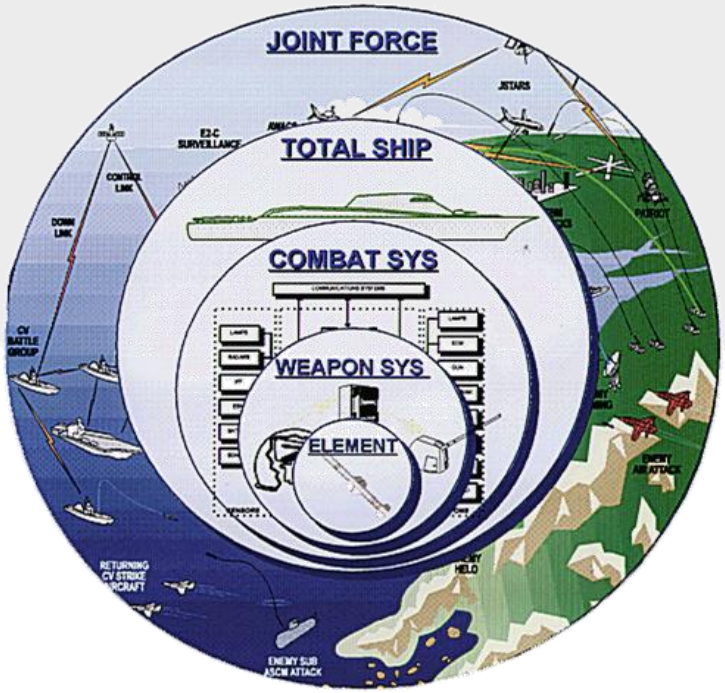
Critical Combat Systems Engineering Aspects

Force-Level Assessment

Combat System Optimization

Building the Pyramid of Expertise

SYSCOM and Warfare Center Collaboration



Enhance NSWCDD's success to support the objectives and implementation of technical authority in early stage design

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Force-Level Assessment

Force Requirements Evolution Roadmap

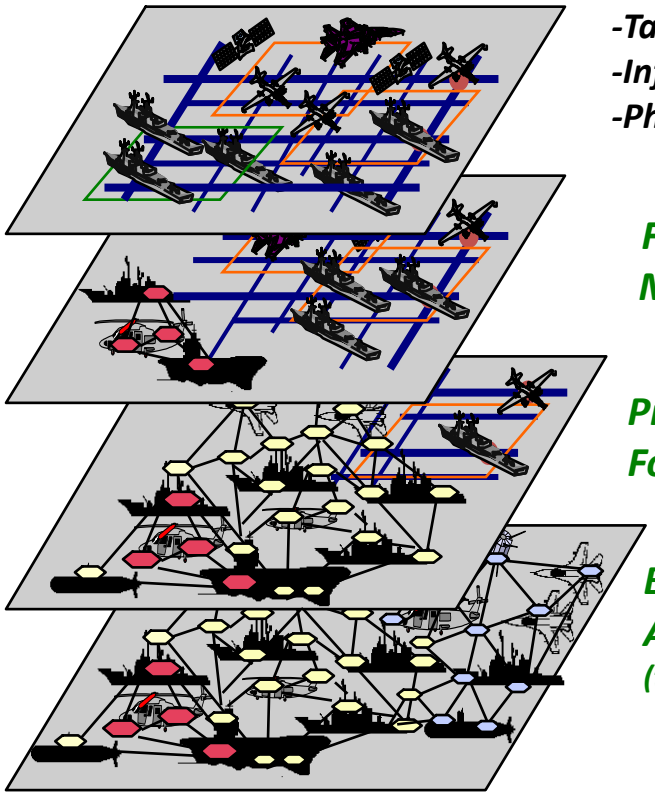
Force Strategic Planning

Vision Force
- *Joint CONOPS, Force Structures*
- *Joint Mission Areas*
- *Service Responsibilities*
- *Op Concepts and Capabilities*

Naval Force Desired Capabilities
- *Op Forces and Tac. Groupings*
- *Threat*
- *Mission Success Criteria*
- *C2 Concept*
- *Performance Categories (UJTL) and Thresholds*

Projected Baseline Force Capabilities

Baseline Force Capabilities



Vision Force Architecture
- *Command Architecture*
- *Task Architecture*
- *Information Architecture*
- *Physical Concepts*

Force Architecture Migration Strategy

Projected Baseline Force Architecture

Baseline Force Architecture
(to Ship and Component System Level)

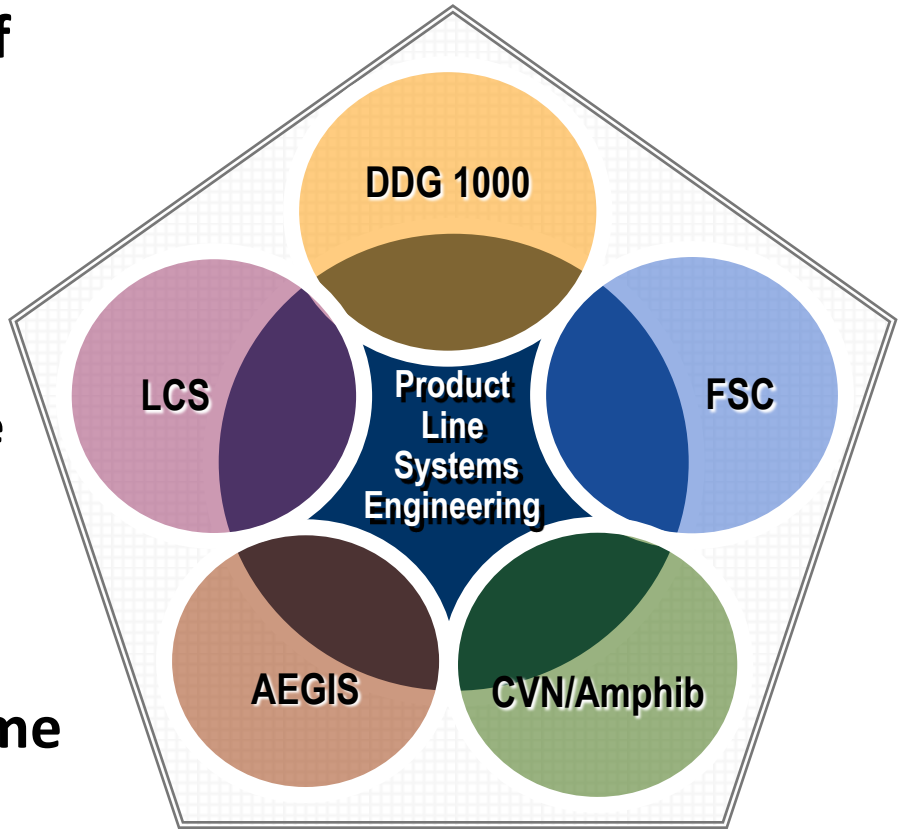
Force Architecture Roadmap

The Evolving Mission Architecture

The Evolving System and Technical Architecture

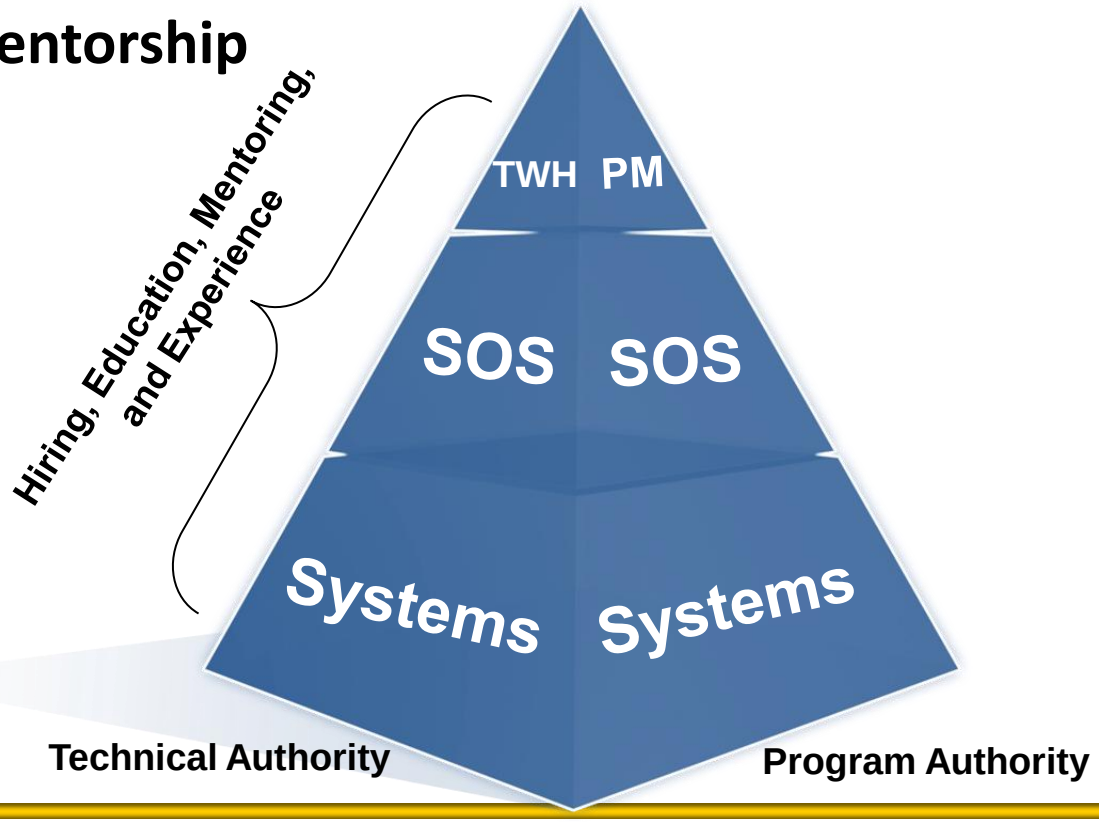
Combat System Optimization

- Enterprise mindset in the face of fleet force reductions
  - Opportunities for information networking and intelligent, coordinated, force-level, tactical decision making
  - Pursuit of product line architecture
- Strike a balance between performance improvement and variant reduction
- Analysis and engineering of "game changer" technologies (e.g., Air and Missile Defense Radar, Rail Gun, Laser Weapon System)



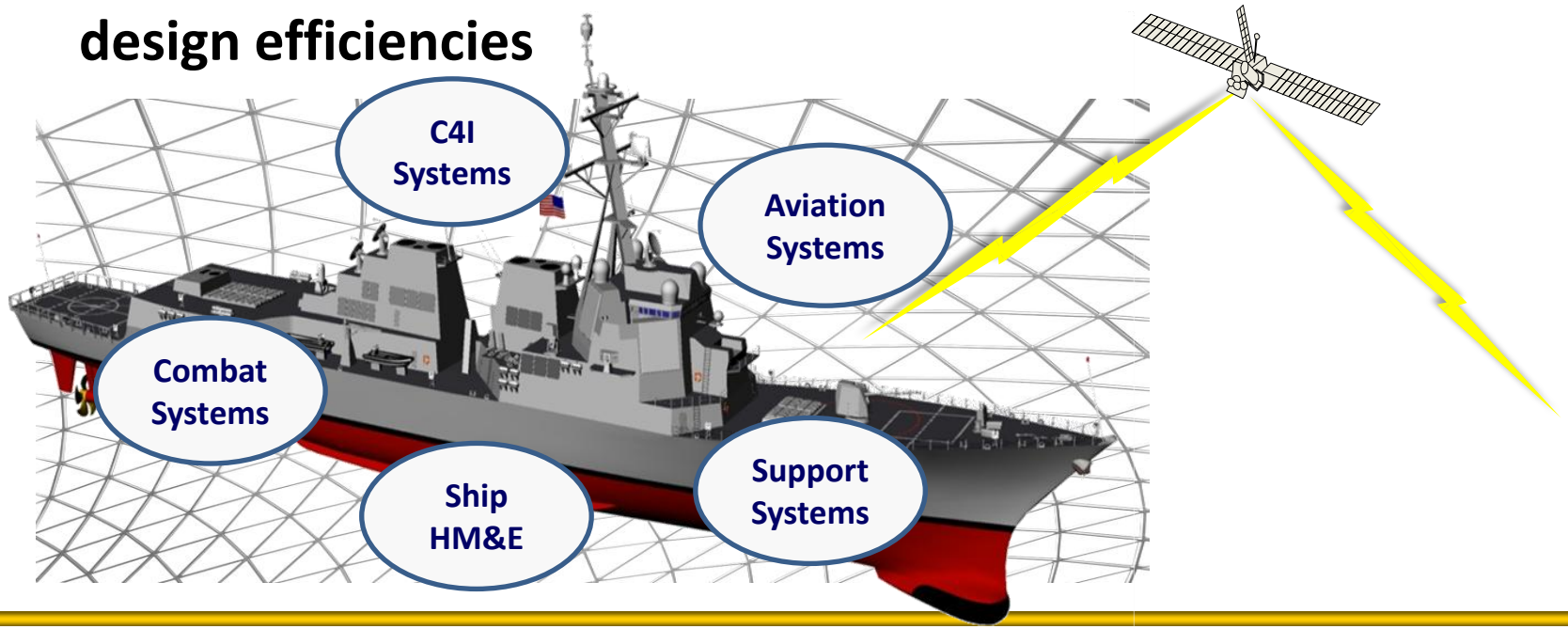
Building the Pyramid of Expertise

- **Workforce development to ensure enduring technical capabilities**
- **Implications of hiring practices, continued education, rotations, and mentorship**



SYSCOM and Warfare Center Collaboration

- Interacting and partnering with both government and industry
- Process improvement for collaboration with other design areas (e.g., ship, C4I [Command, Control, Communications, Computers, and Intelligence], aviation, support) for total ship design efficiencies



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Summary

- NSWCDD is a crucial component in the application of technical excellence in early stage ship and combat system design
- It is of utmost importance to apply these technical capabilities to force- and enterprise-level perspectives
- Combat system efforts must be integrated with other ship design disciplines

Executing the Government's Technical Role for the Navy

Questions

U.S. Navy-released photo